X-RAY Imaging using HERA- Teacher Manual

Overview
Using the HERA imaging software, students will be able to manipulate images to view them in various energy levels. The data are from satellites, which detect x-rays and gamma rays from objects such as black holes, neutron stars, galaxies, and supernovae. Using HERA to compare images will allow students to come to their own conclusions about what is contained in the images. HERA allows students to use the same software that astronomers use on the same data sets that astronomers analyze. This is a great way for students to experience the process of science from data collection to conclusion in the same way NASA scientists do.

Grade Level
Students in grades 9-12

Time Required
Two 50-minute class periods. *This activity can be extended depending on the interest & ability levels of students.*
- Period 1: Complete Engagement & Section I Activities
- Period 2: Continue to Section II Activities

National Standards
Participation will enhance understanding of the following NSES standards:
- Content Standard A: Skills & Processes Grades 9-12 (specifically those below)
  - o Formulate and revise scientific explanations and models using logic and evidence.
- Content Standard B: Physical Science Grades 9-12 (specifically those below)
  - o The total energy of the universe i constant. Energy can be transferred by collisions...light waves...other reactions. However, it can never be destroyed. As these transfers occur the matter involved becomes steadily less ordered.
  - o Waves transfer energy when they interact with matter o EM waves include ...x-rays and gamma rays...the energy of EM waves is carried in packets whose magnitude is inversely proportional to the wavelength.

Participation will enhance understanding of the following MD core learning goals:
- Goal 2: Concepts of Earth/Space Science (specifically those below)
  - o Expectation 1: The student will use a variety of resources to identify techniques used to investigate Earth and the Universe.
    - 2) The student will describe current efforts and technologies used to study the universe.
- Goal 1: Skills and Processes (specifically those below)
  - o Expectation 4: The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.

2) The student will analyze data to make predictions, decisions or draw conclusions.
6) The student will describe trends revealed by data.
8) The student will use models and computer simulations to extend his/her understanding of scientific concepts.

Student Objectives
Students will be able to:
1. Gain a better understanding of how to come to conclusions based on data gathered by other scientists.
2. Analyze data to make predictions, decisions or conclusions.
3. Compare & contrast the effectiveness of using different energies from the electromagnetic spectrum.
4. Describe current efforts and technologies used to study the universe.

Materials

Teacher:
• PC or Mac with capability to download HERA program (Test at school site before using with class)
• Computer with internet access
• Copies of PDF files for students
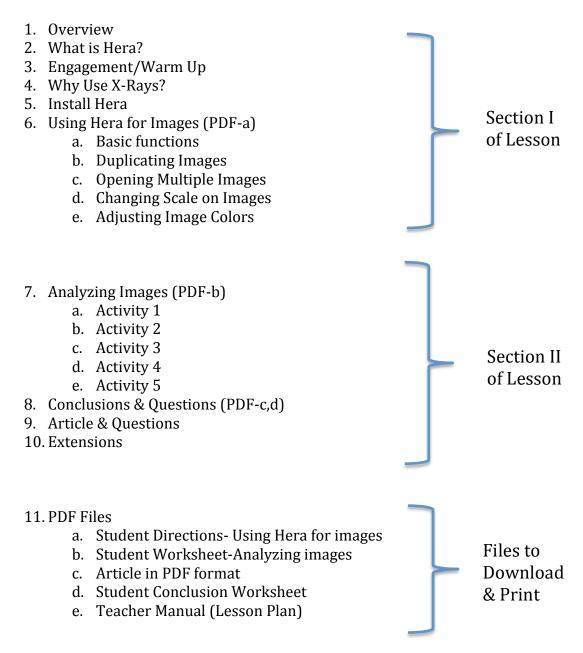
Student (for each or for each pair)
• PC or Mac with HERA program
• Computer with internet access
• Copy of the Student Worksheet(s)
• Pen/Pencil

Materials Special Note: Teachers may choose to download the Hera software to computers at their school before allowing students to access them. This eliminates confusion and makes the lesson run more smoothly. Us the instructions on the following webpage to install Hera:
http://imagine.gsfc.nasa.gov/teachers/hera/install/install_hera.html

Website Format

A brief outline of the site is listed below. Please note that the site has been divided into Section I & II activities. This allows for you to complete the lesson in two class periods.

1. Overview
2. What is Hera?
3. Engagement/Warm Up
4. Why Use X-Rays?
5. Install Hera
6. Using Hera for Images (PDF-a)
    a. Basic functions
    b. Duplicating Images
    c. Opening Multiple Images
    d. Changing Scale on Images
    e. Adjusting Image Colors

Section I of Lesson

7. Analyzing Images (PDF-b)
    a. Activity 1
    b. Activity 2
    c. Activity 3
    d. Activity 4
    e. Activity 5
8. Conclusions & Questions (PDF-c,d)
9. Article & Questions
10. Extensions

Section II of Lesson

11. PDF Files
    a. Student Directions- Using Hera for images
    b. Student Worksheet-Analyzing images
    c. Article in PDF format
    d. Student Conclusion Worksheet
    e. Teacher Manual (Lesson Plan)

Files to Download & Print

Lesson Plan Section I

Engagement

- Use the following as a Warm –up type question t   get students thinkin about the topic.
- Creating an overhead or handout of the dialogue for students to read would be desirable.

The following is a dialogue between a teacher and a student; use it to answer the question below.

Teacher: "Well, my first question is, how many days of the week begin with the letter T?'"
Student: "Shucks, that one's easy. That'd be Today and Tomorrow."
Teacher: (eyes opening wide) " That's not what I was thinking, but...you do have a point though, and I guess I didn't specify, so I will give you credit for that answer."
Teacher: "How about the next one? How many seconds in a year?"
Student: "Now that one's harder, but I've thought and thought about that and I guess the only answer can be twelve."
Teacher: (astounded) "Twelve! Twelve! How in the world could you come up with twelve seconds in a year?"
Student: "Aw, come on, there's gotta be twelve, January second, February second March second. . . "
Teacher: "I see where you're going with it. I guess I see your point, though that wasn't quite what I had in mind, but I'll give you credit for that one too.

- o Explain why you think it is important for scientists look at things from different perspectives.
- o What kinds of tools can scientists utilize to observe items from different perspectives?

- Discuss with students that during their activity today they are going to utilize tools that scientists do in order to look at data from different perspectives.

Teacher note: This "warm –up" is also the third page students will come to on the Hera site. You could choose to conduct this activity in the computer lab as a group or have students complete it at their individual computers.

Exploration I

1. Students should go to the Student Hera page in to the Imagine the Universe! website http://imagine.gsfc.nasa.gov/docs/teachers/hera/
2. Then select the "Using Hera for Images" Activity in the lower-left sidebar.
3. Students should begin by reading through the "Overview" page and the "What is Hera?" page. These two pages allow them to explore the concept of what X-ray imaging and Hera try to accomplish.

4. If the engagement has not already been completed, students can do this on the site. The engagement situation allows students to begin exploring the concept of why scientists would want to view data in different manners.
5. Students should continue on through the site until they reach the "Using Hera for Images" section. The "Using Hera for Images" section of the site will take students through a guided activity in which they will learn about the different tools of the Hera program and how to analyze the images using different tools.
6. This section helps students to become comfortable with the functions of Hera so that they can move on to analyzing other images in Section II of the lesson.
7. Specifically, the "Using Hera for Images" section helps students to explore the following functions of Hera:
    o Basic functions
    o Duplicating Images
    o Opening Multiple Images
    o Changing Scale on Images
    o Adjusting Image Colors
8. Students should stop work here for the day (unless there is more time). This is the end of the activity fo   Section I of the Lesson.

Explanation I
1. As students work through the "*Using Hera for Images*" portion of the site the site will be providing the information necessary for students to be successful in Exploration II.
2. "*Using Hera for Images*" explains the tools of Hera to the students while allowing them to use them and explore them on their own with a sample image.
3. Through these pages, students will explore the concept of viewing data through a series of different energies and how these perspectives can help scientists uncover new information.
4. The pages of the site are very self-explanatory and lead students from the background of collecting scientific data all the way to manipulating data and analyzing it on their own (in section II).

Evaluation I
1. Students can self evaluate and decide how comfortable they are with certain functions. If need be they can go back and practice certain functions or partner up with someone to make sure they understand the functions of the Hera program.
2. Students will be self-evaluating and going back to the directions in "*Using Hera for Images*" as needed to apply the skills they have learned in the independent practice activity.
3. At the end of day one ask students to describe why scientists would want to manipulate data using Hera. Students should be able to describe the benefits of looking at data using different tools from their exploration of the tools of Hera.

Lesson Plan Section II

Exploration II
1. Students should log back into the site and pick up at the *"Analyzing Images"* tab from the menu.
2. The *"Analyzing Images"* section of the site will take students through a series (activity 1-5) of activities in which they will analyze data sets using different energies from the X ray portion and Gamma Ray portion of the Electromagnetic Spectrum.
3. While doing this they will begin to see the benefits of looking at data in different ways.
4. Students can use the worksheet *"Student Worksheet for Hera"* that is available as a PDF download as a way to record the work they do and analyze the images. Teachers can print out copies of the *"Student Worksheet for Hera"* in advance to give to students to complete as they work through the site.
5. Working independently on a data set will develop their understanding of the software and will again illustrate the importance of using different tools to look at the same data.

Evaluation II:
1. Teachers can also collect the *"Student Worksheet for Hera"* in order to assess student learning and assess how well students completed comparing images using Hera.
2. A classroom discussion can be held regarding students responses to the last question on the *Student Worksheet for Hera*. What do the students believe the object they found to be? Did they have trouble finding another object? Possibly have one student share their manipulated image with the others so that all can see the third SNR remnant in the Vela Region image.

Explanation II & Closure
1. Have students read the article called *Radioactive Decay in Supernova Remnants* at: http://imagine.gsfc.nasa.gov/docs/features/exhibit/cgro_snr.html.
2. This article is also available as a print out from the PDF section on the Imaging with Hera Site.
3. Teachers can have students complete the *Hera Concluding Activity Worksheet* (also in PDF), which asks students to tie their experience of manipulating images to the articles content.
4. The article discusses the actual discovery of a third SNR in the Vela Regio and the process that scientists used to find the remnant. This process is much like the one the students went through to find the SNR and is a great way to share with students how the activity ties in to "real-world" science.

A. Currently, there are no new data sets for Hera Imaging. To have students try another activity involving the Hera, click below on Hera Timing Analysis. This activity involving Hera analyzes the orbits of X-Ray Binaries!

Hera Timing Analysis
http://imagine.gsfc.nasa.gov/docs/teachers/hera/

B. If your students are more interested in the topics explored in Hera imaging check out some of the links below!

ROSAT guest Observer Facility: Learn more about ROSAT that collected the data used in Hera Imaging Activities!
http://heasarc.gsfc.nasa.gov/docs/rosat/rosgof.html

History of X-Ray Missions a timeline with information on each mission
 http://imagine.gsfc.nasa.gov/docs/sats_n_data/xray_missions.html

Supernova Remnants (SNR): learn more about what they are and why they are important
http://imagine.gsfc.nasa.gov/science/objects/supernovae1.html